PULSE: Self-Supervised Photo Upsampling via Latent Space Exploration of Generative Models

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Abstract

The primary aim of single-image super-resolution is to construct a high-resolution (HR) image from a corresponding low-resolution (LR) input. In previous approaches, which have generally been supervised, the training objective typically measures a pixel-wise average distance between the super-resolved (SR) and HR images. Optimizing such metrics often leads to blurring, especially in high variance (detailed) regions. We propose an alternative formulation of the super-resolution problem based on creating realistic SR images that downscale correctly. We present a novel super-resolution algorithm addressing this problem, PULSE (Photo Upsampling via Latent Space Exploration), which generates high-resolution, realistic images at resolutions previously unseen in the literature. It accomplishes this in an entirely self-supervised fashion and is not confined to a specific degradation operator used during training, unlike previous methods (which require training on databases of LR-HR image pairs for supervised learning). Instead of starting with the LR image and slowly adding detail, PULSE traverses the high-resolution natural image manifold, searching for images that downscale to the original LR image. This is formalized through the “downscaling loss,” which guides exploration through the latent space of a generative model. By leveraging properties of high-dimensional Gaussians, we restrict the search space to guarantee that our outputs are realistic. PULSE thereby generates super-resolved images that both are realistic and downscale correctly. We show extensive experimental results demonstrating the efficacy of our approach in the domain of face super-resolution (also known as face hallucination). Our method outperforms state-of-the-art methods in perceptual quality at higher resolutions and scale factors than previously possible.